DOCUMENT RESUME

ED 133 683 CS 003 084

AUTHOR	Duffy, Thomas M.; And Others
TITLE	Language Skills: A Prospectus for the Naval Service.
INSTITUTION	Navy Personnel Research and Development Center, San Diego, Calif.
REPORT NO	NPRDC-SR-76-3
PUB DATE	Oct 75
NOTE	55p.
EDRS PRICE	MF-$0.83 HC-$3.50 Plus Postage.
DESCRIPTORS	Adult Basic Education; *Armed Forces; Educational Programs; Language Skills; *Literacy; Readability; *Reading Ability; *Reading Level; *Reading Materials; Reading Programs; Reading Research
IDENTIFIERS	*Navy

ABSTRACT

Concern about the discrepancy between the reading ability of naval personnel and the level of reading material they must deal with in a naval career prompted the study summarized in this report. Focusing on literacy standards and on meeting the standards of reading difficulty and reading ability, the report discusses short-range research and development (R&D) requirements, mid- and long-range R&D recommendations, R&D program delimitation, comprehensibility factors, adjunctives and alternatives to written text, training programs, an overview of needed research on the reading process, a basic reading program, and prospects and requirements for the future. A list of references is included. (JM)

****
* Documents acquired by ERIC include many informal unpublished *
* materials not available from other sources. ERIC makes every effort *
* to obtain the best copy available. Nevertheless, items of marginal *
* reproducibility are often encountered and this affects the quality *
* of the microfiche and hardcopy reproductions ERIC makes available *
* via the ERIC Document Reproduction Service (EDRS). EDRS is not *
* responsible for the quality of the original document. Reproductions *
* supplied by EDRS are the best that can be made from the original. *
****

ED133683

U S DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

Special Report 76-3

October 1975

LANGUAGE SKILLS: A PROSPECTUS FOR THE NAVAL SERVICE

Prepared by

Thomas M. Duffy
with
John D. Carter
John D. Fletcher
Edwin G. Aiken

Reviewed by
John H. Steinemann

Approved by
James J. Regan
Technical Director

Navy Personnel Research and Development Center
San Diego, California 92152

US003 084

FOREWORD

This study was conducted in support of Task Area PF55.522.011, the Assessment and Enhancement of Prerequisite Skills, which is concerned with all prerequisite or enabling skills which underlie a wide range of Navy tasks. This report focuses on reading, but other enabling skills include writing, computations, listening, and speaking. The summary section of this report is intended to serve as a comprehensive overview of the recommendations and underlying rationale contained in the report. The summary itself is considered to be sufficient documentation for the nontechnical reader.

Widespread concern has been voiced over an apparent mismatch between the reading ability of naval personnel and the reading requirements they encounter in a naval career. Since reading is a skill prerequisite to all naval careers, a mismatch of skills and requirements could have widespread consequences for fleet effectiveness. This report provides a review of the area with suggestions for an R&D program as well as management actions which would help reduce the problem of matching skill and requirements. While the focus of the R&D recommendations is on the Naval services, many of the recommendations should be applicable to a variety of settings.

J. J. CLARKIN
Commanding Officer

SUMMARY

Background

The Navy, and the Armed Forces in general, has expressed increasing concern over the presumed mismatch of the reading ability of personnel and the reading difficulty of printed materials. This concern has been reflected in many recent conferences and reports coming from all branches of the service as well as the Department of Defense.

Clearly, reading is essential to job performance if personnel are to operate autonomously, since they must be able to go directly to primary information sources, which are always in a written format. Even when co-workers are available as an alternative means of obtaining information, it was found that the large majority of naval avionics technicians considered the manual essential to the performance of their job. Further, research indicates that both better readers and those making greater than average use of manuals demonstrate a higher level of performance on actual job tasks. Finally, research indicates that reading is essential at all levels of job experience and that the need to read increases with rate classification.

The effectiveness and efficiency of job performance, therefore, will be reduced to the extent that the reading difficulty of job materials exceeds the reading ability of personnel, i.e., to the extent that there is a literacy gap. Reading ability level has been assessed using commercially available tests, and therefore is typically expressed on a scale referring to the years of education of students performing at a comparable level on the test. Reading difficulty level refers to the reading ability (reading test score) which has been demonstrated or inferred as necessary to readily comprehend specified material. The median reading ability of recruits in San Diego has been found to be at the 10.5 grade level, with 25% reading below the 8.7 grade level. This can be compared to the reading difficulty of materials faced early in training (10.2 to 11.5 grade level) and to the difficulty of training school materials (average 14.0 grade level). These data indicate a sizable literacy gap, with 25% of the recruits reading five grade levels below the average difficulty of the training materials.

Projections as to the Navy of the future indicate a decrease, with some fluctuation, in reading ability. The reading difficulty of material will not change unless positive action is taken to simplify materials. Evaluation of alternative formats and media indicates that in all cases language is involved and thus simplification of language (written or spoken) will still be necessary.

Thus, the application of advancing media technology alone will not reduce the literacy gap, while the knowledge explosion will likely increase it. Language comprehension skill will therefore be as essential in the Navy of the future as it is in today's Navy.

Literacy Standards

In reducing, or hopefully eliminating, the literacy gap in the Navy, literacy standards must be established for both reading ability and reading difficulty. Specification of a literacy standard for each naval occupational area and skill level is not a suitable approach since (1) the technology does not exist for either assessing or writing to highly specific levels of difficulty and (2) manpower utilization and job opportunities would be limited. A more reasonable goal, given present technology, is the development of a Navy-wide standard for reading ability and for reading difficulty. This, however, is not a suitable approach because it is not operationally feasible given the range of ability and difficulty.

It is recommended that two reading level standards and two reading difficulty standards be implemented. First, no Navy material should be written beyond the ninth grade level of difficulty--a level above which 75% of enlisted personnel read. Further, all personnel should have the opportunity to attain the ninth grade reading level. However, since this reading difficulty standard exceeds the reading ability of 25% of the current enlisted personnel, a substantial portion will not attain the ninth grade level, even with a reading training program. Thus, a second reading difficulty standard, sixth grade, is recommended for a limited number of occupational areas. This level also would be the minimum acceptable level of reading ability for naval service. Those personnel reaching the sixth grade but not the ninth grade reading level would be limited, initially, to the specified occupational categories.

Short range research efforts in support of establishing the recommended literacy standards involve establishing the distribution of reading ability in the force and projecting the number of personnel falling below the 6.0 and 9.0 reading levels. Additionally, occupational areas where a 6.0 reading difficulty standard would be feasible and effective must be identified. The modifications of reading material which will be necessary to attain the 6.0 level must be determined.

The recommended literacy standards are the most reasonable alternative given the present lack of data on literacy requirements. Even within the present recommendations, there is uncertainty

as to the meaning of "sixth" and "ninth" grade levels. There is even greater uncertainty as to the degree to which reading ability must match reading difficulty. While the short-term research would aim at implementing a dual literacy standard, the following longer-range research would address assessment problems and possible adjustments in the standards.

- The tolerable literacy gap. The tradeoff in performance and the loss in comprehension as the gap between reading ability and reading difficulty increases must be determined.

- Usage difficulty. Research must be conducted to determine whether the various indices of reading difficulty reflect the ability required for typical job usage and, if required, to develop an index of the reading ability needed to find and use job-relevant information.

- Reading ability, reading difficulty, and job performance. Further efforts are required to determine the extent of the relationship between reading and job performance.

- Assessment of reading ability. A reading test is needed which reflects adult comprehension on a scale which is functionally significant to the Navy. This effort will also require further examination of adult comprehension processes.

- Assessment of reading difficulty. An index of reading difficulty applicable to Navy materials and men has recently been developed. Validation of this index is required. The index would serve as an immediately useful assessment tool while alternative assessment methodologies were being evaluated.

Meeting the Reading Difficulty Standards

Ideally, the difficulty of a concept, rather than the difficulty of the writing style, should be the limiting factor on what an individual can comprehend. The need to simplify technical writing is not limited to the Navy or even to the Armed Forces. Preparation of written materials accompanying man-machine systems, as well as technical writing in general, is an important area of human factors engineering that has been almost entirely neglected.

The R&D recommendations for material preparation herein apply only to comprehensibility factors in the production of new materials, with retrofitting only in limited areas.

The program recommendations for meeting reading difficulty standards focus on (1) determining those characteristics of text which lead to greater comprehension and (2) developing procedures for assuring that the final product is written at the specified level of reading ease. Text characteristics promoting comprehension include written and graphic text, as well as text supplements such as job performance aids and advanced media techniques. These efforts must

consider the varying characteristics of the materials (e.g., conceptual level, procedural versus descriptive information, etc.), the user personnel (e.g., reading ability, level of experience, etc.), and the environment in which the materials are to be used (schoolhouse, confined area, etc.).

Style guides are available to assist writers in preparing comprehensible materials. It is argued, however, that style guides alone will not be adequate for assuring a comprehensible product. The Navy has recognized the need for training programs in all other occupational areas. Simply giving a man written instructions for his job (be it welder or instructor) has not been viewed as adequate. In a similar manner, a writer training program should be implemented for Navy writers and personnel involved in verification and validation. Additionally, the development of cost effective procedures for verifying and validating the comprehensibility of the written materials is required. R&D in support of meeting the reading difficulty standards are required in the following areas:

- Program delimitation. Determine those areas where retrofitting of current materials is necessary to provide increased comprehension.

- Graphic assessment. Develop a metric for assessing graphic comprehension.

- Graphic production. Test and evaluate alternative graphic formats for specified personnel, tasks, and environments.

- Text-graphic integration. Develop procedures for effectively interrelating text and graphics.

- Text comprehension. Summarize factors affecting text comprehension. Programmatically test and evaluate the relevancy of the factors for specific work situations.

- Alternative media and format. Summarize information on existing job performance aids and media and classify them as they apply to specific work environments. Programmatically test and evaluate the classification scheme.

- Advanced media. Continue and initiate, as necessary, research efforts on advanced media techniques, e.g., computer-based training and maintenance.

- Writer training. Design, develop, and evaluate a program for training writers, verifiers, and evaluators in techniques of clear writing. Determine training options for contracted writers.

- Graphics training. Explore the potential for developing a training program on techniques for comprehensible graphics production.

Meeting the Reading Ability Standards

Reading training is viewed as a necessity for meeting the recommended sixth and ninth grade standards. The goal of the reading programs should be to prepare personnel for occupational training and thus, should focus on the vocabulary, formats, and concepts which will be encountered during a Navy career.

The success of reading training programs will depend, in large measure, on how well we understand the problems of adults who read poorly. Research in reading currently consists of a voluminous assortment of fragmented studies with little integration. In general, however, it seems reasonable that reading instruction should be based on the following five aspects of the reading process: perception, decoding, vocabulary, literal comprehension, and interpretive comprehension.

These aspects of reading span the reading process from physiological limitations of reading to the complex and little understood process of applying world knowledge to draw inferences from what is literally written. While considerable research has been conducted in each aspect, the efforts have not been programmatic and do not focus on procedures for training adult readers. Such a programmatic effort promises major payoffs for the Navy.

It is recommended that the reading enhancement training program (training to the ninth grade level) be voluntary and be available to all personnel on shore and as much as possible, aboard ship. Such a program will provide training when a man views it as necessary and will capitalize on his motivation to learn.

The basic reading program (training to the sixth grade level) should prepare personnel for the basic reading requirements faced in the Navy. As such, the training should occur as early as possible and the training materials should be derived from the materials used during recruit and apprentice training. Since the sixth grade standard is viewed as the minimally acceptable reading level, this program would of necessity be mandatory. Basic reading programs are already operational at the Recruit Training Centers. Thus, implementation of the recommended program requires an extension of the present program and a modification of materials and, perhaps, instructional procedures.

These reading training programs are recommended with reservation since past and current attempts in this area have met with very limited success. The proposed programs, however, offer greater promise of affecting performance and job satisfaction since: (1) a series of programs rather than a one-shot program is proposed,

(2) the programs focus on Navy materials rather than general reading, and (3) material revision will occur in conjunction with reading training so as to achieve an ability-difficulty match. To the extent that these recommendations are implemented, the probability of a successful reading training program is increased. The long- and short-term R&D efforts required to produce an effective program are in the following areas:

- Reading process. Conduct programmatic research in the areas of perception, decoding, vocabulary, and literal and interpretive comprehension as they pertain to reading training for adults.

- Reading program plans. Determine the number of personnel who would participate in each program and the extent to which existing programs (e.g., GED) meet the requirements.

- Reading program development. Develop and scale Navy-relevant materials which are appropriate for training reading. Develop training objectives and procedures for meeting the objectives. Develop procedures for individualizing training where necessary.

- Reading program evaluation and refinements. Evaluate the reading programs and, on the basis of the evaluation, refine materials and training procedures.

CONTENTS

	Page
INTRODUCTION	1
Reading and Job Performance	2
Is There a Reading Ability--Reading Difficulty Mismatch?	5
The Navy of the Future	8
LITERACY STANDARDS	13
Occupational Specific Standards	13
A Navy-Wide Standard	15
Recommended Standards and Supporting R&D	15
Short-range R&D Requirements	16
Mid- and Long-range R&D Recommendations	17
MEETING THE READING DIFFICULTY STANDARDS	21
R&D Program Delimitation	22
Comprehensibility Factors	23
Adjunctives and Alternatives to Written Text	28
Training Programs	29
MEETING THE READING ABILITY STANDARDS	33
Overview of Needed Research on the Reading Process	33
Reading Enhancement Program	36
Basic Reading Program	37
Prospects and Requirements for the Future	39
REFERENCES	43
DISTRIBUTION LIST	49

INTRODUCTION

The Navy, and the Armed Forces in general, has recently expressed increasing concern over the presumed mismatch between reading ability of personnel and the reading difficulty of printed materials used by these personnel. Printed materials in the form of manuals, instructions, and regulations are the major source of job and service information. Thus, the inability to comprehend these materials is viewed as a major impairment to effective job performance. This concern for the effects of a disparity between reading ability and reading difficulty, i.e., a literacy gap[1], was expressed in a Department of Defense statement as follows:

> This obvious gap between the available reading skill and the apparently required skill has implications for supervisory behaviors, training needs, job knowledge, job proficiency achievement, and perhaps the development of job data. The observed difference between literacy skill and need can cause significant delays in developing journeyman job proficiency and can create problems in obtaining effective manpower utilization (McGoff & Harding, 1974, pp. 5-6).

A similar concern was expressed in the Navy Enlisted Occupational Classification System (NEOCS) Study Group report (1974). This group was tasked with examining the current Navy Enlisted Classification System and recommending modifications in view of the changing Navy. Of the ten priority R&D recommendations made by the Study Group, seven involved basic skill training in reading and improving the reading difficulty of Navy materials. The basis of this concern is expressed in Volume II of the NEOCS Report as follows:

> The only anticipated difference between pre-Vietnam enlistees and the individual of the future is a decreasing reading ability level. Accordingly, major efforts must be made to simplify course books, training manuals, maintenance manuals and other publications to accommodate this deficit. It may also be necessary to increase remedial reading training during the early phases of a man's training (1974, p. 85).

---

[1] Reading ability refers to the reading level demonstrated by personnel on a standard reading test. Reading difficulty refers to the difficulty of specific textual materials, i.e., the reading ability demanded by the material for adequate comprehension. Reading difficulty is usually measured using one of the various readability formulas. A literacy gap exists when the reading difficulty of material is greater than the reading ability of the personnel. Since reading ability and reading difficulty scores are typically expressed in terms of school grades, the determination of a literacy gap is made by comparing the grade levels.

Further indication of the importance attached to reading skill requirements in the Navy was expressed in a July 1974 conference on basic skill training in reading hosted by the Chief of Naval Personnel (Pers-6)[2] and March 1974 conferences on reading training and readability hosted by the Chief of Naval Operations (Op-099). One of the CNO conference findings stated that "Reading capability levels in the enlisted force, ... can be taken as one of the significant indicators of skills required to perform satisfactorily on the job."[3] This conclusion is consistent with the unanimous agreement reached at the 1972 worldwide on-the-job training conference that reading problems existed and were proving detrimental to the conduct of Air Force on-the-job training (see Mockovak, 1974a).[4]

The general purpose of this paper is to examine the role of language skills, and reading in particular, on job performance in the naval service. This will largely consist of examining the extent of the reading ability-reading difficulty mismatch problem in the current and future Navy, setting forth alternative approaches to its solution, and identifying R&D issues.

Reading and Job Performance

The first question to consider is how essential reading is in a Navy career. Clearly, there are a vast number of training and technical manuals, written job instructions, Navy instructions, and safety standards information. These written materials are the major means of disseminating information about all phases of Navy life. An individual may receive this information in discussions with his co-workers or supervisor. However, if he is ever to operate autonomously, he must be able to go directly to written sources of information. In terms of independent functioning, personnel must be able to read relevant Navy and job materials.

Is reading essential? Given that reading is an important skill, the question still remains as to whether it is essential to effective and efficient job performance, particularly in cases where the amount of reading required may be minimal or other information sources (e.g., interpersonnel communications) may be adequate substitutes. There

---

[2] Adult Basic Skills Training Workshop report Pers-611c:TJK:der, Ser: 591-74 of 5 Aug 1974.

[3] Chief of Naval Operations (Op-099) speedletter 991B/550 of 13 March 1974. Readability Level of Publications and Adult Basic Skill Training.

[4] In this regard, Air Force Manual 50-23 states that the ninth grade is the desired reading level and specifies that airmen deficient in reading skills must take steps to improve their reading ability.

are several research findings indicating the importance of reading to job performance in a variety of occupational areas. All of the studies began by surveying personnel to determine the frequency and nature of job-related reading. In most studies it was assumed by definition that reading is a necessary job skill if personnel report that they make frequent use of written materials and that the reading is necessary for the job. When reading is found to be necessary for a job, this means that personnel must have not only basic reading skills, but also the ability to read at a level commensurate with the relevant job materials.

Byrd, Kidd, and Price (1970) evaluated the effectiveness of Navy avionics manuals through a survey of the manual users. In response to specific questions, 82% of the users surveyed reported heavy usage of the manual and 81% indicated the manual should be kept in the work area. Only 11% disagreed with the statement that "One should never start a new job without reviewing the proper manual." Finally, relevant to the consideration of interpersonnel communication as an alternate source of information, only 13% of the users felt that co-workers may offer more information about a job than the manual.

The Byrd et al. (1970) results indicate that avionics manuals are necessary for the job and are heavily used. Given the need for avionics manuals, a specification of the reading difficulty of the manuals would serve as an indicator of the reading ability that personnel in this area should have for effective job performance. This specification, along with slightly different usage assessment procedures, was undertaken in a study of several Army occupational areas (Sticht, Caylor, Kern, & Fox, 1971). Personnel in three different occupational areas were interviewed to determine the amount and content of job-relevant reading engaged in by personnel in each occupational area during the previous month. Then, by determining the reading ability necessary to understand these specific materials, Sticht, et al., (1971) were able to specify the reading difficulty personnel face in each job area. These were found to range from the seventh to the twelfth grade levels.

Does reading ability affect performance? The above studies assume that if personnel report reading on the job, then reading is by definition a necessary component of job performance. A more direct assessment of the importance of reading to job performance would involve the determination of the relationship or correlation between reading ability and some measure of job performance. This procedure, however, involves several difficulties. First, since reading ability and general aptitude were found to be highly related (Madden & Tupes, 1966; Caylor, Sticht, Fox, & Ford, 1973), it follows that people with higher general aptitude scores (as reflected by IQ and Armed Forces Classification tests) tend to be better readers. Thus, if a relationship is found between reading and job performance, it may only reflect the fact that better readers have a higher aptitude and therefore perform better on the job. The second difficulty involves choosing a measure of job performance. Actually having personnel perform jobs and scoring that performance is time consuming and expensive. Certainly, the procedure would not be employed on a large scale. The alternative is to use

an index related to job performance. The most obvious such measure is supervisor ratings of performance. Unfortunately, this measure, while having face validity, has often shown little relationship to the ability of a man to do a job. Sticht et al. (1971) found correlations of .13 to .24 between supervisor ratings and actual ability to do a job in four Army occupational specialties. Ronan & Prient (1971) discuss many of the considerations which enter into supervisor ratings and make clear that one would not expect these ratings to accurately reflect job performance.

Despite the measurement difficulty, Sticht et al. (1971) present evidence that suggests that reading ability does relate to job performance. They asked Army personnel in the cook, repairman, and supply specialist areas to indicate what specific job material they had read in the previous month. For all personnel but those in the cook specialty, the amount of reading increased with the reading ability of personnel. Similar questions were asked concerning whether information was sought from co-workers or supervisors. The use of this information source remained constant across levels of reading ability. Therefore, better readers were seeking more job-relevant information than poorer readers. Next, Sticht et al. gave personnel in the supply specialist and repairman ratings job sample tasks - actual tasks selected to reflect the key jobs performed by men in the occupational area. Results showed that performance on these tasks increased with the reading ability of the personnel. Thus better readers were better able to perform the job. This finding, as discussed previously, may simply reflect the fact that better readers have a higher general aptitude and therefore do a better job. In an attempt to circumvent this problem, Sticht et al. (1971) divided personnel in each specialty into those who reported using the manuals on the job and those who did not. At each reading level and for each specialty, those personnel who reported that they used the manual performed better on the job task than those who reported that they did not use the manual.

The Sticht et al. data, as it bears on the reading-job performance relationship, may be summarized as follows.

Better readers perform a job task with a greater proficiency than poorer readers. But, since reading and general aptitude are related, it is reasonable to assume that the effects on job performance may be due to aptitude rather than reading ability. However, manual users are better at performing job tasks than manual nonusers. Here it appears more reasonable to assume that reading rather than aptitude will determine the tendency to use manuals. If this assumption is accepted, then it may be concluded that reading ability--independently of aptitude--does indeed affect job performance.

The necessity of reading and job experience. While the above research clearly indicates that reading ability is an essential job skill, it may be that this is only true when personnel first enter an occupational area. That is, with job experience and advancement,

personnel may become sufficiently familiar with their equipment and job requirements so that the need for reading is minimal. However, research evidence indicates that just the opposite is true. The need for reading is similar for experienced and inexperienced personnel and, importantly, the reading requirements increase with advancement. Byrd et al. (1970), in their survey on avionics manuals, found that avionics personnel, regardless of experience, expressed a preference for the manual as an information source. With regard to advancement, an Army survey[5] found that only 2% of total reading was reported as job-related by E-1 personnel. This proportion increased with rate until E-8s reported that fully one-fourth of their reading was job-related. The only deviation from increasing reading demands with increased rate was for E-9s who reported that 16% of their reading was job-relevant. A similar conclusion regarding the importance of reading ability for advancement may be reached from an Air Force survey of reading improvement programs (Mockovak, 1974a). The survey included all reading improvement programs conducted at Air Force bases in the continental United States. It was found that 90% of the bases had reading improvement programs. The major reason given by most students (55%) for participating in the programs was difficulty encountered in reading and comprehending career development course material. A much smaller number (28%) reported a need for acquiring basic reading skills. These findings point to reading as an essential skill throughout a man's career. More importantly, they suggest that the level of reading ability which is sufficient to perform at an entry rank of an occupational area may not be adequate for advanced rates. Thus, given considerations of manpower utilization, and the opportunity to pursue a satisfactory Navy career, personnel should either have the reading ability necessary for advanced rates or be provided the opportunity to attain the necessary reading level.

Is There a Reading Ability--Reading Difficulty Mismatch?

The previous discussion clearly indicates that reading ability is related to job performance. To the extent, then, that the reading difficulty of job materials in the various Navy occupational fields exceed the reading ability of personnel, the effectiveness and efficiency of job performance will be reduced. The next question to consider is whether there is a mismatch between the reading ability of personnel and the reading difficulty of the materials they use on the job and as a part of their Navy career, i.e., whether there is a literacy gap.

A direct answer to this question would require examining the reading ability of Navy personnel in specific job areas in relation to the specific job reading material used by these men. Unfortunately, a systematic examination of this nature has not been undertaken with Navy personnel. Enough information is available, however, on the

[5] Survey Estimate of Subject Area of Most Reading for Self-improvement and Primary Reason for Reading. Army Male Personnel. Op-OPM Report No. 29-68-E, Office of Personnel Operations, Personnel Management Development Office, 28 February 1968.

reading ability of Navy personnel in general and the reading difficulty of Navy materials in general to suggest that a literacy gap of sizeable proportion does exist.

Reading ability. Carver (1974a) assessed the reading ability of a sample of recruits using an unpublished reading comprehension test. He found the average reading ability of incoming recruits to be at the grade 9.5 level. Duffy, Nugent, Millar, & Carter (1974) tested the reading ability of all incoming recruits at the Recruit Training Center (RTC), San Diego, during the period May to August 1974. They used the Gates-MacGinitie test, a commercially available test geared for primary grade students. The median recruit reading grade level on this test was 10.5. Thus, 50% of the recruits at RTC San Diego were reading below the 10.5 grade level, and 25%, below the 8.7 grade level.

To say that a recruit reads at a grade level of 8.7 means that he can answer questions about elementary school type of prose material about as well and as quickly as a student in the last half of the eighth year of school. The implications of this statement for using reading tests in the Navy will be discussed in a later section. For present purposes, however, the important consideration is that the test provides a scale of reading ability. While the scale is specified in grade levels (and grade levels will be referred to in this report), the scores should be interpreted only as an ordinal scale indicating, for example, that a man reading at the 8.5 grade level reads more poorly--as gauged by the test--than a man reading at the 10.5 grade level. The data from Carver (1974a) and Duffy et al. (1974), then, provide a scaling of reading ability of Navy recruits. For comparison purposes, Caylor et al. (1973) found that the median reading level of Army recruits at Fort Ord was 9.7. While current data is not available for Air Force personnel, the median reading ability was estimated to be 11.8, with 25% reading below 9.3 in 1965 (Madden and Tupes, 1966).

Reading difficulty (readability). Scaling the reading ability of personnel is the first step in determining whether there is a literacy gap. It is also necessary to rank the reading difficulty of Navy materials on a scale related to the reading ability scale. This involves developing readability indices. For Navy personnel this is done by taking personnel whose reading ability scores are known and testing their understanding of Navy materials. In other words, they are given reading comprehension tests on Navy materials. The reading difficulty of the material is then the reading ability score (previously determined) at which most men (75%) having that score understand most (75%) of the Navy material. Thus, the stated reading difficulty of materials can be directly related to the reading ability score of the personnel. If, by this method, the reading difficulty in a particular area is determined to be 12.0 and 90% of the men in this area have a reading score less than 12.0, then a literacy gap is clearly indicated.

The procedure for assessing reading difficulty as outlined thus far provides the framework for the many readability indices which have been developed. Almost all of the indices (see Klare, 1963; 1974-1975)

begin by relating the understanding of a passage in some way to the reading ability score of the people tested. The appeal of readability formulas is that they go one step further and relate common factors of difficulty, e.g., word and sentence length, to the reading difficulty score. Thus, rather than having to repeatedly test people on each passage in order to determine its difficulty, physical parameters of the text are indexed and used to derive a reading difficulty or readability score.

A readability formula, because it goes beyond testing people on a passage, is restricted in applicability to the type of people and material initially involved in developing the index. Further, its use is restricted to assessing already written material rather than serving as a guide for writing. Unfortunately, since all readability formulas but one were developed on nontechnical materials, their applicability to the Navy is questionable.

The FORCAST formula (Caylor et al., 1973) is the only readability index developed using Armed Forces personnel and materials. This was done by relating Army recruits' comprehension of Army manuals to their reading ability scores. The passages, thus scaled, were also found to differ in the proportion of one-syllable words. Consequently, the final index uses the proportion of one-syllable words to derive a readability or reading difficulty score. One reservation which may prevent a wide application of the formula in the Armed Services derives from the fact that it was developed using recruits. These personnel were likely to be unfamiliar with the Army manuals and therefore would have lower comprehension scores than experienced personnel. Thus, the application of this formula should primarily be directed at assessing the reading difficulty of manuals to be used in initial training in an occupational area.[6]

Keeping the above caution in mind, the FORCAST formula has been used to assess the reading difficulty of a variety of Armed Forces material. The results indicate that, on the average, the materials are written at the eleventh grade level. Duffy et al. (1974) assessed the difficulty of Navy training manuals for the airman, seaman, and fireman rates, and found that the average readability of the text was 10.5, 10.3, and 10.2 respectively. Further, they found the readability of the Navy General Classification Test was 10.9. Similar results were obtained by Mockovak (1974b) in applying the FORCAST formula to five Air Force career development manuals. The readability of these manuals ranged from 11.1 to 11.4. Finally, Caylor et al. (1973) found that the readability of twelve Army manuals ranged from 7.6 to 13.2, with a median grade level of 10.8.

---

[6] CHNAVTECHTRA has recently developed readability indices based on personnel and material in Navy training schools (Kincaid, Fishburne, Rogers, & Chissom, 1975). Thus, these indices, if valid, will apply to the reading difficulty faced by trained personnel.

Several additional studies of the reading difficulty of Navy materials have been completed using readability indices developed on public school students and materials. As discussed previously, use of the indices for Navy materials is questionable. However, in all of the studies using the FORCAST formula, the results were compared to the reading requirement as assessed by the formulas based on general text. Considerable difference in reading requirements were found for individual manuals. However, when the average reading requirement of several manuals was taken, the general text-based formulas and the FORCAST formula yielded comparable results. Thus, the readability studies using other formulas can be interpreted as yielding accurate average information.

Fattu and Standlee (1954), in an early assessment of reading difficulty, found that Navy materials which are generally used by lower ability personnel are at the high school level of difficulty. Mowry, Webb, and Garvin (Undated) found the reading difficulty of several naval aviation manuals to be at the high school and college level. More recently, Carver (1974b) assessed the difficulty of 20 Navy manuals and found the average readability to be 14.8, with a range of 11.7 to 20.0.

The purpose of this section was to determine whether there is a mismatch of reading ability of personnel and reading difficulty of material. The Duffy et al. and Carver findings indicate that the median and average reading ability of recruits is at about the 10th grade level. This is contrasted with the assessment of reading difficulty which indicated in general that Navy material is written to the level of grades 11 to 14. The Chief of Naval Operations (OP-099) conference on readability proposed that materials should be written so as to be comprehendable by at least two-thirds of the intended users. Since the Duffy et al. study found that two-thirds of the recruits at RTC San Diego read above the 9.5 level, it appears that an overall mismatch exists of approximately three grade levels. Clearly, the finding that some manuals are written at the grade 16 level and above suggests even a greater literacy gap in some occupational areas.

The Navy of the Future

Given that the present Navy faces a literacy gap which may be expected to hinder job performance, the question arises as to whether this gap will exist in the Navy of the future. Will technological advances, the use of computers, and reorganization of the naval enlisted occupational classification system reduce reading difficulty in the future, and can the Navy expect to obtain better readers in the future? In answer to the last question, the NEOCS Study Group report (1974) projects that the reading ability level will decrease to 9.0 in the 1980s. This projection is based in part on a Brookings Institute report (Binkin & Johnston, 1973) which states that the services will acquire more personnel with moderate AFQT scores than with above average scores. Although this prediction will show perturbations as a function of the national unemployment level, it is probably tenable over the long range.

It is also unlikely that technological advances in and of themselves will reduce the volume or difficulty of reading required in the Navy. Indeed, the "information explosion" associated with advancing technology suggests that the amount of reading required of personnel will be greatly expanded. The NEOCS Study Group (Vol. II, 1974) projected that nontechnical skill requirements will remain unchanged in the future. However, in discussing electronic innovations, they state, "Though these innovations will minimize the technician's manual skill requirements, they will also force training into areas of total systems knowledge and interface support (p. 47)." Thus, the Navy technician of the future will be required to have a broad range of knowledge which will likely require an increased amount of reading.

While the information processing requirements placed on future personnel may increase, it is hoped that information presentation techniques of the future may drastically reduce reading difficulty. For example, computer printouts might list instructions or descriptions of materials, video tape might provide audio and visual presentation of information, and compressed speech tape recorders might replace manuals. These various information presentation techniques emphasize, in general, simplified listings in written format, pictorial information in place of written text, or auditory presentation. Each of these alternatives will now be discussed in terms of reading difficulty.

Simplified writing. Simplified written text presentation, which includes the listing format of fully proceduralized job performance aids, can clearly reduce reading difficulty. However, the various formats will not reduce the amount of material that must be read. Additionally, in order to reduce reading difficulty, improvements are required in the organization of materials and the vocabulary used. That is, the reduction will not be a fallout from technological advances so much as from an active effort to determine procedures for simplified writing. The reading difficulty in a computer printout, television listing, or any form of list presentation of the written word can be just as great as the difficulty encountered in reading text.

Pictorial presentation. Reducing the amount of reading material by pictorial presentation on videotape, computer terminals, or through holography similarly will not automatically reduce reading difficulty. Since all forms of pictorial presentation serve to supplement language (auditory or written) presentation, the use of such pictorial presentation involves problems similar to the use of manuals with their mixture of text and pictorial information. Pictures, whether they are diagrams, photos, or live recordings, can reduce the amount of reading required. However, if pictorial supplement is to be effective, it is still necessary to select the proper picture to supplement the text, to organize the sequence of presentation, in the most effective manner, and to choose the proper vocabulary and syntax to effectively describe the picture.

Problems in using a manual are not only due to vacabulary and sentence length, but are also caused by improper or inadequate indexing, difficulty in relating pictures to text, poor organization of the information, etc. These same problems are present regardless of whether the information is presented in a manual or through computer or video tape. Thus, procedures developed to solve these problems in any one medium of presentation will provide information for improvements in the other mediums.

Auditory presentation. An alternative to written text is tape recorded information for audio presentation. In this way, the argument goes, reading problems will be bypassed. For illiterate (below the grade 4 reading level) personnel, the use of audio tapes clearly would facilitate comprehension. In general, personnel at this reading level might be expected to increase three grade levels by using audio presentation. However, even with this increase, the linguistic material which these personnel could deal with would still be quite restricted.

Once phonics skills are learned, typically at grades 3 or 4, the effectiveness of audio presentation relative to the written format begins to diminish. Intuitively, this is what one would expect, since with phonics ability a man can translate the written word into speech. Sticht, Beck, Hauke, Kleiman, & James (1974), in a survey of reading and listening comprehension, found that reading and listening comprehension scores were identical by grade 7. Prior to grade 7, listening comprehension was better than reading comprehension, with the difference diminishing between grades 4 and 7. This survey, which included 37 individual experiments, clearly points to the comparability of listening and reading ability once beyond the stages of initial reading. This does not mean that the skills involved in reading and listening are used equally. Clearly, listening requires a greater use of memory than reading but benefits from auditory uses of syntax like intonation and pausing. Overall, however, once phonics skills are acquired, little difference in the reading and listening ability is found.

Evidence as to the comparability of listening and reading ability in the Armed Forces is also available. Sticht (1969) compared the listening and reading comprehension of high and low ability Army personnel. Again, no difference was found as a function of modality regardless of the general mental ability of the personnel. On the basis of this and similar findings, Sticht et al. concluded, "For practical purposes, measures of readability can be used as measures of listenability (1971, p. 50)." Thus, in our discussion of reading requirements, we have really been discussing language comprehension requirements, which includes both auditory and written language. Similarly, reading ability should also include listening ability, at least for readers above seventh grade.

Clearly, unless action is taken to improve the match of language difficulty and language comprehension, job performance in the future Navy may be expected to suffer. The reading (language) ability of future personnel is expected to decrease while the reading (language)

demands due to the information explosion of advancing technology are expected to increase. Although future technology will provide advanced presentation aids in the form of video and auditory systems, computer-assisted instruction, and holography, these presentation aids will only supplement presentation of language information in either the auditory or printed format. Thus, the comprehension requirements presently demanded by the language information must be reduced. Further, improvements must be made in (1) integrating information presentation aids and language presentation, (2) integrating pictorial and text information, and (3) sequencing and indexing information. Since these requirements apply to all forms of information dissemination, improvements in any one format may be expected to facilitate design in others.

LITERACY STANDARDS

In reducing, or hopefully eliminating, the literacy gap in the Navy, consideration must be given to both the establishment of literacy standards and the development of mechanisms for attaining those standards. This section of the report is concerned with the establishment of literacy standards, i.e., the minimum acceptable reading ability of Navy personnel and the maximum acceptable reading difficulty level of Navy written materials.

Occupational Specific Standards

It has been proposed that reading ability and reading difficulty standards be determined for each occupational area and skill level. Thus, under the proposed NEOCS, separate literacy standards would be specified for each skill level in each of the 29 occupational areas. This classification scheme offers several advantages when compared to the alternative of a single Navy-wide literacy standard. First, the assessment necessary to develop occupational specific literacy standards would provide in-depth information on reading requirements faced in the Navy. Second, the reading ability standard established for a specific area could serve as a classification instrument along with the currently employed classification measures of arithmetic skills, general aptitude, etc. Finally, the extensive material revision required under a single Navy-wide literacy standard would be greatly reduced, since no revision would be necessary in cases where the level of the written material matches or is less than the reading ability of the personnel.

There are, however, several disadvantages of the occupational-specific scheme which must be considered. These involve consideration of manpower utilization and occupational opportunity, material preparation requirements, and the availability of adequate assessment instruments.

The occupational area-skill level specific standards would be determined in part by the reading ability of the incumbent personnel. Research discussed previously indicated that reading demands increased with rank. Thus, it is likely that the reading ability standards within an occupational area also would increase with rank. This means that personnel could have the required reading ability to enter into an occupational area but would not meet the standard for advancement. In this way, the literacy standards would constrain both the opportunity and the availability of personnel for advancement. A similar limitation in the availability of personnel for various occupational areas would also exist. These limiting effects would increase in the future if

the reading ability of personnel decreases as projected. Although these effects could be corrected when they become severe by either changing the reading ability standard or providing increased reading training, neither corrective action would be easily implemented. Adjusting the reading ability standard would also require an adjustment of the reading difficulty standard of material if the standards are to be meaningful. Hence, extensive material revision would be necessary. Although an increased reading training program could be implemented, it would be costly since it would have to span a wide range of reading levels--from the basic reading level to that of the highest reading ability standard.

Another disadvantage of occupational area literacy standards comes from the resultant multiplicity of specifications for the reading difficulty of textual material. The problem here is two-fold. First, additional literacy standard(s) would be required for materials written for Navy or system-wide distribution, such as information used in recruit training, Navy and system instructions, and safety standards. Thus, there would be literacy standards for each occupational area-skill level, as well as those for the individual systems commands, enlisted personnel as a whole, etc. Clearly, the potential for an unwieldly number of literacy standards exists. Second, and more basically, it is not feasible given present technology to specify the procedures to be followed in writing to specific levels of difficulty. The difficulty of a passage depends on word and sentence difficulty, sentence structure, paragraph length, concept difficulty, and general writing style. Little is known about how these features, in combination, affect difficulty. Within present technology it would be possible to specify successive steps to be taken in writing in a more readable manner. Specifications of this nature could result in roughly three categories of difficulty, e.g., the 6th, 9th, and 12th grade levels. Thus, the detailed specification of occupational reading standards would have to be converted to these more general categories.

A final disadvantage of developing occupationally specific literacy standards involves our inability to obtain precise measurements of both the reading difficulty of material and the reading ability of personnel. This problem is present even with a service-wide literacy standard, and would become more acute with the specification of precise literacy standards for each occupational area. As Caylor et al. (1973) found, the literacy requirements for an occupational area will vary by several grade levels, depending on whether a readability index, job performance test, or job knowledge test is used to assess the requirements. The literacy level was also found to differ as a function of whether materials formally specified for the job or the materials personnel actually reported using were measured. Thus, it would not be within the present state of the art to specify literacy standards as precisely as the occupational area plan would require.

A Navy-Wide Standard

Given the considerations of manpower utilization, job opportunity, and methodologies for the preparation and assessment of materials, it is recommended that separate literacy standards for each occupational area not be adopted. A more realistic goal, given present technology, is the development of Navy-wide standards for the reading ability of personnel and reading difficulty of materials. These standards would serve as guidelines for improving reading ability and reading difficulty while R&D is undertaken to more adequately specify literacy standards. However, while specification of such standards is technologically feasible, the logistics involved in implementation make the approach unrealistic. Fully 25% of incoming recruits read below the 9.0 grade level, while manuals generally are written to at least the 10.0 grade level and often to the 14.0 and 15.0 grade level. It is unrealistic to set a single literacy standard--a level to which both men and materials should be matched--when a literacy gap of this magnitude exists. In addition, such a standard appears to be unnecessary since reading ability is related to GCT and other basic test battery scores. This relationship will, in itself, limit the eligibility of low reading ability personnel for many occupational areas.[7]

Recommended Standards and Supporting R&D

On the basis of the above considerations, it is recommended literacy standards of ninth grade and sixth grade levels be established for reading difficulty. No Navy material should be written at a difficulty level greater than 9.0. Given our present knowledge of reading ability, this level of difficulty will allow adequate comprehension by 75% of Navy enlisted personnel. The 6.0 reading difficulty standard would be applied to specified occupational areas. Within the specified areas, no material would be written above the 6.0 level. Implementation of this reading difficulty standard will require a strong emphasis on written and graphic job performance supplements to the textual material. Decisions as to the number of occupational areas to which the 6.0 standard would apply must be based on the number of personnel expected to read below the ninth grade level when a full Navy reading plan is implemented. The specific occupational areas to which the 6.0 standard would apply must be determined on the basis of current reading requirements (amount and difficulty of reading), the feasibility of simplifying

---

[7] The basic test battery-reading relationship likely is due in part to the verbal nature of the tests. However, a correlation, albeit weak, is found between reading and nonverbal aptitude tests.

the written material, and the reading ability of personnel currently classified in the area. In making these assessments, consideration must be given to the reading requirements at all points in a man's career, i.e., trainee and all ranks.

Similarly, reading ability standards should be established at the 6.0 and 9.0 level. The minimum required reading ability for any job area would then be 6.0. To accomplish this goal, mandatory reading training or screening in recruiting would be necessary for approximately 6.7% of incoming personnel now found to read below the 6.0 level. Those personnel reaching the mandatory lower limit but reading below the 9.0 level would be classified into the occupational areas having the lower literacy requirement. Personnel reading above the 9.0 level (about 75%) would not be limited on the basis of reading ability in their choice of occupational areas. Thus, under this proposed program, reading ability would serve as a gross classification index with personnel reading below 9.0 limited in their occupational selection. This system, then, does not fully meet the problems raised earlier regarding manpower utilization and equal job opportunity. However, these problems could be resolved by implementing a second reading training program to train personnel to the 9.0 level. The needs for reading training programs and supporting R&D will be discussed in a later section. In the remainder of this section the short-, mid-, and long-range R&D requirements in support of the literacy standard recommendations are discussed.

Short-range R&D Requirements

Implementation of the above recommendations requires the following short-range R&D program:

1. Assessment of current reading ability in the naval Force.

2. Projection of the number of personnel expected to read below the 9.0 level even when reading training programs are available.

3. Identification, through a survey of systems commands, of those occupational areas in which a 6.0 reading standard would be feasible and effective.

4. Assessment of reading requirements in the identified occupational areas by (1) considering all phases of the career--training and field work at all ranks, and (2) determining through interview the materials actually used by personnel (volume of reading required) and then assessing the reading difficulty of the material using the readability indices developed by CHNAVTECTRA (Kincaid et al., 1975).

Mid- and Long-range R&D Recommendations

The tolerable literacy gap. The recommended literacy program was the most reasonable alternative due in part to our present inability to adequately assess literacy requirements. Even under a service-wide literacy standard, it is only a guess that a 9.0 reading ability is the level needed to comprehend material written at the 9.0 level as determined by a readability index. It will be recalled that a particular FORCAST readability score indicates that 75% of armed forces personnel reading at the level can comprehend at least 75% of the Armed Forces material rated at that level.[8] Little information is available as to how the level of comprehension falls off as the gap between reading ability and reading difficulty increases. Thus it may be that 72% of 8.0 level readers comprehend at least 75% of 9.0 material. If this were the case, then training personnel to the 9.0 level rather than the 8.0 level would be of dubious value and of considerably greater cost.

A parametric investigation of comprehension as a function of the size and source of the literacy gap is needed. For instance, it is likely that a 2-year gap at lower ability levels (e.g., between a sixth grade reader and eighth grade material) is more detrimental than at higher ability levels (e.g., between a ninth grade reader and eleventh grade material) due to the greater change in sentence and vocabulary across lower grade levels. Also to be considered is the experience level of the personnel. With job experience, technical vocabulary and procedural familiarity are increased. Hence, the written matter is serving more and more as a supplement to background knowledge and the readability of the material may be expected to be less critical. Indeed, for well experienced personnel, comprehension may be unaffected by the size of the literacy gap within normal ranges of reading ability.

Usage difficulty. A second long-range R&D project in the assessment area involves an examination of the effects on reading difficulty of how the material is used. In specifying the readability of written material, we are really attempting to specify the level of reading ability required to effectively use the material in a job or training situation. The underlying concern is usage difficulty, i.e., the reading ability necessary to use a manual in obtaining job-relevant information.

Work in this subproject would be exploratory in that procedures for assessing usage difficulty would first have to be developed. Usage difficulty would then be related to reading ability and reading difficulty (readability) measures. If the relationship of usage difficulty

---

[8] The readability formulas developed by Kincaid et al., 1975 have the same interpretation except that the materials are relevant to the man's occupational area.

and reading difficulty is low, then an effort would be made to develop reliable and valid indices of usage difficulty. This effort is required because of the concern that the readability indices currently available may not be valid indications of the reading ability required to effectively use job reading materials. This concern can be exemplified in terms of both the construction and application of the readability indices. In initially constructing these indicies, comprehension of standard or exemplar passages has been assessed in recent years, by asking personnel to fill in words which have been systematically deleted from the passage.[9] This type of reconstructive comprehension may require a considerably greater reading ability and inferential ability than the typical job reading comprehension task, where a man must assess the relevance of a sentence to his task and, if relevant, know how to undertake the prescribed action.

In both constructing and applying the readability indices equal weight is given to all sections of a written document and to all sentences within a section. Implicit in this process is the assumption that the reading task is to read and comprehend all sentences in the document. Clearly, this is not the case. First, all sections are not equally relevant. Some sections are more critical to effective job performance than others. Thus, in assessing usage difficulty, the various sections should be weighted accordingly. Second, a typical job reading task involves searching out information. Thus, the comprehension task amounts to effectively skimming material until the relevant paragraph, sentence, or word is found. A measure of usage difficulty, then, would assess the reading ability necessary to find and comprehend relevant job information rather than assess sentence by sentence comprehension.

Reading ability, reading difficulty, and job performance. Continued efforts along the lines of the Caylor et al. (1973) research is needed to determine the interrelationship of the various measures of reading difficulty and the relationship of these measures to job performance. That is, literacy demands may be assessed using either the materials which are prescribed or the ones actually used. Further, the difficulty of the material may be assessed through the application of readability indices, job knowledge tests, or actual tests of ability to perform specified job tasks. Exploration of the interrelationship of these measures and their interpretation has only begun.

The only research relating reading ability directly to job performance has been that of Sticht et al. (1971) discussed previously.

---

[9] This is a Cloze test (Taylor, 1957), which was used to develop the FORCAST formula and the CHNAVTECHTRA (Kincaid et al., 1975) indices.

This work, which involved three Army occupational specialties, needs to be extended to a wider variety of occupational areas taking into account the work environment, the technical sophistication required, and the reading ability of personnel currently classified in the occupational area. This project could be undertaken at the same time the various reading difficulty measures were being compared.

Assessment of reading ability. Reading difficulty levels of materials are always stated in terms of school grade levels. This is because the measures are developed using performance of personnel on a reading ability test designed using school children as a standard. The question of how a Navy ninth grade reader differs from a ninth grade school student must be answered. Since the school-based reading tests were developed to distinguish children in various age categories with particular levels of experiential background, their validity in determining adult reading ability is questionable. Certainly the adult has a much broader experiential background, and as a result, should be able to comprehend materials which the school child could not. Similarly, adult strategies in reading and in interpreting material are likely to differ from those of the child. In like manner, the typical reading test material is related to school material and classroom ways of thinking, and hence are likely to be interpreted differently (and on the basis of scoring, incorrectly) by the adult.

The difficult question of what a reading test measures has been the subject of much debate. An Armed Forces (Navy) program is needed to examine the nature of adult reading comprehension processes from the perspective of the military reading requirements. The goal of this long-term, exploratory research, should be the development of a reading test that relates to some background indicant of adult experience, such as years of experience in a topic area, years of formal education, or a similar measure. Initial work, however, would entail research into those factors which affect adult comprehension. In developing this reading test for Navy use, this exploratory work should focus on the interaction of personnel characteristics and material characteristics.

Assessment of reading difficulty. The assessment projects discussed thus far are long-range projects. On a mid-range basis, a measure of reading difficulty is needed which is based on experienced personnel reading material in their job area. As noted previously, the FORCAST formula was developed using recruits and Army material unfamiliar to them. This index is not necessarily predictive of the difficulty which experienced personnel will face with the material. The readability indices recently developed by CHNAVTECHTRA are based on the comprehension of job area materials, by school personnel, and should be valid in predicting the difficulty experienced men will face. However, the validity of these indices (i.e., whether they work on a new set of material) must be determined.

To summarize, recommended mid- and long-term research and development efforts in literacy assessment are:

1. Determination of the effects that varying literacy gaps, level of reading ability, and topic familiarity have on comprehension.

2. Measurement of usage difficulty and other indices of comprehension of written materials.

3. Determination of the interrelationships among reading ability, the various measures of reading difficulty, and job performance.

4. Exploration of adult reading comprehension processes and development of a measure of adult literacy relevant to Navy needs.

5. Validation of the CHNAVTECHTRA readability indices.

MEETING THE READING DIFFICULTY STANDARDS

Previous sections have outlined the scope and severity of the literacy gap in the Navy. A dual standard for writing Navy materials (e.g., manuals, regulations, instructions, etc.) was recommended. The specific levels of difficulty within this dual standard were tentatively recommended as the ninth grade level for all materials except in specified areas where a sixth grade level would apply. This section deals with the nature of the program and the associated R&D needed to implement the recommended reading difficulty standards.

Before addressing the R&D requirements, it should be emphasized that the recommended standards refer to writing style and format. Ideally, the difficulty of a concept, rather than the difficulty of the writing style, should be a limiting factor on what an individual can comprehend. Given adequate communication of ideas in Navy materials, personnel should be able to optimize their effectiveness in training and job performance. Specifying the ninth grade standard implies that writing should serve to simplify and explain rather than add complexity. An examination of any ninth grade science book will readily indicate that ninth grade writing does not involve "See Dick run" sentences. In such writing, jargon is avoided when possible and explained when it must be included; long, cumbersome sentences are avoided; ideas are clearly ordered and main points emphasized; and illustrations are commonplace. In essence, ninth grade writing is clear writing.

The recommendation to write to the sixth grade level for specific occupational areas again refers to writing style rather than concept difficulty. Here, however, since some personnel have limited facility with the written word, greater emphasis will be placed on illustrations and job performance aids.

The need to simplify writing to more effectively communicate ideas is not limited to the Navy or even the Armed Forces. However, the problem is more acute in the services. Navy enlisted personnel are selected from a population where the average citizen reads less than one book a year. These personnel are then placed in a situation where reading is required to not only learn an occupation but to learn an entirely new life style. Thus, the reading demands are clearly greater than those for comparable groups in civilian life.

The need for simplified writing outside of the services is aptly illustrated by Chapanis (1965) in his presidential address to the Human Factors Society. Chapanis points to the written material accompanying man-machine systems, as well as scientific writing in general, as an important area of human factors engineering that is almost entirely neglected. Several examples presented by Chapanis indicate that clear presentation of ideas - in brief safety warnings and instructions as well as long technical documents - requires more than short sentences and words. To illustrate, in a large hospital a sign was placed by all elevators

which read: "Please walk up one floor and walk down two floors for improved elevator service." Most people encountering the sign interpreted it to mean that they would find better elevator service on the other floors and proceeded accordingly. However, the actual meaning was: "To go up only one floor, or down two floors, please walk."

The failure to write clearly can have more serious implications. For example, again as cited by Chapanis, a large container bore the tag:

> Warning: The batteries in the AN/MSQ-55 could be a lethal source of electrical power under certain conditions.

An additional tag had been placed on the container on which someone had printed a more apt warning: "Look out! This can kill you!" Finally, Conrad (1962) illustrated how poorly worded instructions can impair job performance. Subjects were asked to transfer a call from one phone to another on a private telephone system in Great Britain. One group was given the actual instructions printed by the telephone company and posted on the phones. Only 20% of the subjects successfully completed the task. However, when the same number of words was used but certain key sentences were rearranged, 78% could transfer the call.

These above examples indicate the need for clear writing throughout society. Proper writing saves time, not only in reading but also in performing the task described, and decreases the possibility of error. The need for clear statements where safety is involved is self-evident.

R&D Program Delimitation

The subject matter of this report, and thus the scope of the R&D recommendations, is the comprehensibility of language materials. The concern is for developing procedures to assure that a specified content is communicated to the intended personnel in an effective, efficient, and acceptable manner. It is recognized that the specific content is a critical determinant of the effectiveness of any document. However, considerations of the relevancy, currency, and accuracy of the content do not lie within the purview of this document.

A second consideration in defining the scope of the program is whether the program should address both the production of new Navy materials and the revision of existing materials to make them more comprehensible. Considering the extent of the literacy gap and the importance of the written word in communication, the program would ideally address all written materials--new and old. However, it is estimated that there are currently 79,000 technical manuals involving 20 million pages (Sulit, 1975). Adding the number of existing training manuals, regulations, instructions, etc., to this figure would likely more than double it. Considering this volume, all existing materials could not be revised within reasonable cost and time constraints. Rather, the program should focus on the production of new materials,

with retrofitting applied only to those critical areas where: (1) the literacy gap is large and performance deficits are evident, (2) the sixth grade level criterion is to be applied, or (3) safety of personnel is a consideration. Before the project can be limited in this way, however, an immediate research effort is needed to determine areas where retrofitting of materials is necessary to make them more comprehensible (including consideration of literacy gap and performance deficits).

Within these confines addressing only comprehensibility and a limited retrofit the R&D program must determine and specify those characteristics of text which lead to greater comprehension for the user personnel, and develop procedures for assuring that the final product is written at the specified level, and determine procedures for simplification. The program must take into account the varying characteristics of the materials (e.g., conceptual level of content, procedural vs. descriptive information, etc.), the user personnel (e.g., reading ability and cognitive style), and the environment in which the materials are to be used (e.g., schoolhouse vs. shipboard, confined area, etc.). While much research has been done on factors which increase comprehensibility, little information exists on relating these factors to the complex of men, type of materials, and environment.

Comprehensibility Factors

Graphics. Graphics presentation is a common supplement to written materials used to emphasize, explain, or provide a practical mnemonic for specific written information. It is not uncommon for 50% of a Navy manual to involve some form of graphic presentation (e.g., figures, tables, photographs, schematics, etc.). Other sources of written information similarly depend on graphic supplementation to highlight and simplify important points (e.g., safety and hazard indicators). Thus, development of procedures to determine the difficulty of graphic material and provide guidelines for effective usage should play a major role in improving comprehensibility of written materials.

The R&D requirements to ensure proper graphic presentation may be classified into three broad categories: (1) assessment of graphics difficulty or comprehensibility, (2) development of procedures to effectively integrate written text and graphics, and (3) determination of effective graphic formats for audiences and communication requirements.

The assessment of graphic difficulty is still in the embryonic stage of development. The difficulty of a particular graphic item is assessed by presenting it to a group of subjects and requiring them to make a response that demonstrates comprehension. This, however, is an expensive and, time-consuming process. A metric, as was developed for measuring readability, is needed that will gauge graphic difficulty without having to test subjects. To develop such a metric, elements which are common to a wide range of graphic items and which relate to their

difficulty must be identified. In developing a metric for measuring readability, the common elements were found to be word length (or difficulty) and sentence length.

The problem involved in specifying common indicants of difficulty for graphic material stems from the enormous array and complexity of graphics. Not only are there a vast number of "different kinds" of graphics (e.g., photographs, schematics, etc.) but the number of potential elements in any one type is almost unlimited. Attempts to specify common elements have included measuring such factors as the black-white ratio, the density of "information units," and the number of "information units" (see, e.g., Post & Price 1974; Siegel & Burkett, 1974). These factors, however, are limited in scope of application, have received little test and development, and are largely based on intuition.

Recent advancements in computer technology now offer the possibility of developing and testing more broadly based metrics for measuring graphic difficulty. In essence, such assessment involves determining which elements are common to a large set of easily comprehended graphics but are not present in a set of difficult graphics. Computer programs for pattern recognition and pattern matching, for instance, offer the possibility of performing such an analysis.

The graphics assessment research effort, in summary, requires the classification of graphics into broad categories, the determination of the difficulty of samples of items in each category, and finally, the determination of elements of the graphics which are related to difficulty. Additional research would determine whether graphics comprehension is related to reading ability or general aptitude of the user personnel.

Developing a metric for measuring graphic difficulty will allow the assessment of a graphic presented in isolation. However, graphics almost always serve to supplement written text with the overall objective being to explain a concept, describe a procedure, etc. Thus, if a graphic presentation is to be effective, it must highlight the appropriate written text and be placed in such a manner so as to provide an integrated text-graphic presentation. To illustrate, Booher (1973), examined the effects of printed text only, pictorial text only, and various mixes of pictorial and written text on job procedures. He found that performance speed and accuracy were differentially affected by the type of format, and, the effectiveness of the mixed presentation depended on what type of information was presented pictorially. Project PIMO (Serendipity, 1969), the SIMM specification (Ortegeis, 1970), and the FOMM specification (Naval Ship Systems Command, 1974) present guidelines for graphic-text integration as it applies to maintenance tasks and, more specifically, to troubleshooting. Extension of this work to other Navy written material is required. A limitation of the previous work is the focus placed on low ability personnel, which meant that graphic presentation was provided wherever possible. This strategy may be unnecessary for higher ability or more experienced personnel and, indeed, may reduce the effectiveness of the communication. The considerations

here are both the cost of graphic production and the effectiveness of the presentation. Thus, future developmental efforts extending previous work should examine how graphics affect performance of personnel who vary in reading ability, general aptitude, and experience.

Finally, a research effort is required to determine which graphic format communicates most effectively in particular situations. There are many situations in which alternative graphic formats can be used (e.g., picture vs. line drawing vs. schematic, video vs. still, etc.). The proposed research effort would evaluate the effectiveness of these alternative formats in a wide variety of Navy relevant situations to determine under what circumstances one particular format may yield a significantly higher level of comprehension. The variables in the research should include personnel characteristics (e.g., experience, reading ability, general aptitude), response requirements (e.g., understanding expressed in a paper and pencil test, performance accuracy, performance speed), and job situations (time pressure or not; classroom, office, field, or workshop environment).

A large volume of research exists which compares alternative graphic formats, including recent reviews of the literature performed for the Army (Kinton, Inc., 1975; RCA, 1974), the Navy (Biotechnology, Inc., in press), and Westinghouse Corp. (Gulliford, 1973). These reviews, which serve as statements of the state-of-the-art, indicate relevant variables to be used in additional research. The additional research will be necessary because research to date has not provided systematic comparisons of graphic formats. Also, since much of the research has involved school children and classroom learning, it is questionable as to whether results obtained will generalize to adult Navy personnel working on a job.

The consideration of alternative graphic formats has clear implications for cost effectiveness both in terms of material preparation and job performance efficiency. For example, McKeachie (1974), in examining previous research, concluded that photographic and video presentation did not improve comprehension over simple graphic presentation forms. A similar conclusion was reached by Wells, Van Mondfrans, Postlewait, & Butler (1973). If this finding is substantiated for the wide variety of Navy-relevant situations described above, it would imply that the costly investment in video hardware and lessonware may be unnecessary. If specific job/personnel situations are found where video is beneficial, its use could be limited to those situations. Dwyer and his associates (1967, 1968, 1969, 1972) in an extended research program similarly concluded that photographs and realistic drawings did not aid learning and, in fact, resulted in lower retention when compared to line drawings. Due to the limited range of instructional materials, however, this conclusion must be generalized with caution. Most certainly the efficacy of realistic graphics will depend on the instructional purpose. It seems clear, however, that realistic graphics should be reserved for the specific instructional conditions where they can be demonstrated to be effective. More basic research has explored the basis for the retention effect by examining the graphic components

attended to in each format (Loftus and Bell, 1973). The importance of a parametric evaluation of these conclusions is indicated by the results of Booher's (1973) research. He found that the degree of pictorial detail did not affect accuracy of performance, but that it did clearly reduce the time required to perform a job. Similarly, although the data are not available, it might be expected that the effectiveness of pictorial detail (schematic to photograph) would depend on the level of job experience of personnel.

In summary, the recommended R&D efforts for graphic presentation include:

1. Development of a metric for assessing graphic comprehension. Exploration of computer technology for assessing graphic difficulty.

2. Determination of procedures for effectively interrelating text and graphics, taking into account the characteristics of the user personnel.

3. Determination of graphic formats which are most effective for specified user personnel, response requirements, and work environments.

Text. In comparison to graphic presentation techniques, a vast array of procedures exist for both assessing the difficulty of written materials and producing written materials that are comprehensible. However, R&D efforts are still required to evaluate the effectiveness of the procedures within specific Navy areas and to ensure the effective implementation of these procedures. With regard to assessment of reading difficulty, the need to develop computer assessment procedures was discussed previously. Also discussed previously was the need for additional research efforts to assure that readability estimates accurately reflect the reading ability required by men using the particular materials. These efforts are needed to assure widespread and accurate use of readability (or comprehensibility) assessment tools.

Numerous style guides exist that present rules for producing comprehensible text. These style guides have been developed for the Armed Forces (Klare, 1974-1975; Post & Price, 1974; Siegel, Federman, & Burkett, 1974; Kern, Sticht, Welty, & Hauke, 1974) as well as for civilian technical and nontechnical writing (e.g., Strong & Eidson, 1971; Gunning, 1952; Brogan, 1973). The recommendations in these guides, for the most part, are based on attempts to abstract basic research findings and apply to the organization of entire passages as well as the improvement of paragraph and sentence comprehension. It is predicted, however, that the implementation of style guides for writers will in and of itself have only a minor effect on improving comprehensibility. This prediction is derived as follows. First, style guides have been available for years. Indeed, the use of writing specifications which contain descriptions of effective writing procedures is an integral facet in the preparation of Armed Forces materials. Yet, as outlined previously, these specifications have not proved adequate for guiding

the production of comprehensible materials. Procedures for increasing the effectiveness of style guides will be discussed in a later section.

A second limitation to the effectiveness of the style guides arises from the nature of the research on which the recommended writing techniques are based. The research, in the main, employed college students as subjects, standard prose (or isolated sentences) as the study material, and a retention measure of rote recall or performance on a paper and pencil test. The research focused on understanding basic processes of comprehension. It did not apply these basic findings to various work situations and reading tasks as found in the Navy. Cronbach (1975), in discussing individual differences and training method interactions, concludes that the host of variables interacting with particular training methods is so large that it is futile to set as the object of research the determination of laws or relationships that generalize to all situations and people. Rather he proposes that research should be directed at the situation of concern. Thus research would answer direct, situation-specific questions. If general laws do exist, they will emerge from the applied research.

While Cronbach (1975) was concerned with instructional techniques, the same argument applies to the production of comprehensible written material. For almost every writing style recommendation, reliable research can be cited that indicates that the factor does not affect comprehension. Indeed, the style guides for writing themselves are inconsistent in style recommendations. Klare (undated) found 156 style recommendations in ten technical and five general writing guides. The maximum level of agreement amounted to six writing guides (less than 50%) making the same particular style recommendations. Further, many conflicting recommendations were found, e.g., keep paragraphs short vs. vary paragraph length, repeat vs. avoid redundancy, etc.)

Given the limited generality of research results and style recommendations, it is questionable whether these rules for comprehensible writing would apply to the wide array of Navy jobs. Certainly different rules would apply, depending on whether the concern was schoolhouse learning, finding repair or operation information, following procedural or troubleshooting instructions, or quickly comprehending a warning. Similarly, the work requirements quick response, accuracy of response, or comprehension of a problem would play a large role in determining the rules for comprehensible writing (e.g., see Booher, 1973, discussed in the previous subsection).

Given these considerations, an R&D effort is required to determine the factors that affect comprehension of text within the context of the wide array of Navy reading requirements. Initially, the factors already identified should be tested. However, recognizing advancing technology, new comprehension factors and new techniques for presenting text must be explored and developed.

The requirement to read textual information is not going to disappear. As noted in the introduction, advancing technology is expected to increase the reading requirements due to the demands for greater system knowledge. Thus, R&D efforts in this area must be programmatic. To determine "What works in what situations," a systematic investigation of comprehension factors across people, jobs, and response requirements within the context of the Navy is required.

In summary, the recommended R&D efforts for production of comprehensible text include:

1. State-of-the-art summarization of factors affecting text comprehension and evaluation of the situation(s) in which the factors are and are not relevant. Included are factors relevant to overall organization, paragraph emphasis, and sentence and word structure.

2. Programmatic experimental evaluation of each comprehension factor within the context of the Navy. This effort would span relevant variations in personnel, task, and environmental characteristics.

Adjunctives and Alternatives to Written Text

There are a wide variety of job-performance aids and media available as alternatives to text. The development efforts here have been long-lived and extensive. There is little doubt that supplements to text which effectively summarize difficult or frequently encountered situations can be of great assistance. Unfortunately, each job-performance aid that is developed is too frequently viewed as the panacea for solving all comprehension and usability problems. The general effectiveness of alternative media is questionable and requires further R&D to determine specific conditions of effectiveness. Since both auditory and video presentation are temporally fixed, they limit the ability of personnel to skim for relevant information. The lack of an advantage of auditory presentation over print as regards comprehension was discussed in the introduction.

The required R&D activities in this area and the rationale for the recommended research are presented in the "Human Factors Development Plan to Support the Navy Technical Manual Systems (NTMS)" (Miller, 1975). These research recommendations are similar to those just presented for text comprehension. The proposed research involves (1) surveying and documenting the wide variety of job-performance aids and media techniques, a state-of-the-art survey, (2) surveying and catalogueing the variety of workplace conditions, types of tasks and hardware, and relevant personnel characteristics, and (3) evaluating, with experimental comparisons as necessary, the effectiveness of each alternative technique across the variety of people, task, and environmental characteristics.

Miller (1975) does not discuss the use of computers as a means of supplementing text. However, industry and the Armed Forces have long

used computers to maintain summaries of necessary information and to provide ready access to that information in an interactive format. Computer aids to troubleshooting for both training and on-the-job use are in various stages of development (Brown, Burton, & Bell, 1974; Bond & Rigney, 1966; Crooks, May, Purcell, Lucaccini, & Freedy, 1974). In addition, shipboard computer-based training in troubleshooting is now under evaluation (Hoyt, Butler, & Hayword, in press). The use of computers as alternatives or supplements to text has the advantage over other audio-visual techniques of providing ready access to necessary information in whatever job-performance aid or other format is appropriate. Computer aiding also allows access to a far greater array of information than would be feasible using job-performance aids. Clearly, the use of computer aids will be limited by the constraints of personnel, environments, and tasks. However, given the rapid expansion of computer technology, the cost effectiveness as well as the range of effective application is continuously increasing. Thus, it is recommended that R&D efforts in the area of text supplements and alternatives include an evaluation of computer aiding and the potential applications of future developments.

In summary, the recommended R&D efforts for adjunctive alternative materials include:

1. Survey and compilation of information on existing job performance aids and media techniques.

2. Classification of environment, training and job task, and personnel characteristics, and evaluation of where each aid and media technique may apply.

3. Programmatic experimental evaluation of the alternative aids and media in each classification.

4. Research on advanced media techniques, e.g., computer-based training and maintenance.

Training Programs

In discussing the development of style guides, it was predicted that implementation of a style guide by itself will not significantly improve the comprehensibility of written materials. The basis for this prediction lies in part in the fact that style guides, either as individual guides or as part of a military specification, have long been a part of the preparation of Armed Forces manuals. Yet the problem of overly difficult manuals still exists.

The emphasis in the selection of manual writers is traditionally and necessarily based on technical expertise. It is simply not feasible to obtain sufficient personnel who are both technically competent and fully versed in techniques for clear writing. Additionally, intuitively,

it does not appear to be effective to present the writer with the style guide without giving him instruction or practice. The Armed Forces have recognized the need for training programs in all other occupational areas. Welders do not become welders simply by reading the manual. Rather, both schoolhouse and on-the-job training and practice is provided. More closely related to writing, potential instructors are required to participate in an instructor training program where instructional techniques and course development are explained and practiced.

Without a training course which provides comparisons of effective and ineffective writing as well as practice of techniques for effective writing, the techniques will not be fully appreciated. Simply reading the guide before writing divorces the guide from the practical situation where it is needed. As in all situations where a book is read before the need for the information exists, relevant material will soon be forgotten. Use of the style guide while writing implies that the writer will recognize his specific need for improvement. However, unless he is given prior instruction and evaluation, a writer may find it difficult to pinpoint his weaknesses and recognize alternatives. While supervisory personnel may be expected to bring style deficiencies to the attention of the writer, the simple fact is that this procedure has not been fully effective in the past. As discussed in the introduction, the Armed Forces is still faced with a large number of overly difficult manuals.

It is strongly recommended that a training program for in-house writers be developed. It is felt that such an effort is a critical component of any program aimed at producing more readable material. The training program could be developed as a correspondence course, and be presented either via video tape and supplementary materials at the writing houses or as a schoolhouse course. The critical factor is the provision for practice and evaluation in techniques for clear writing.

The needs and requirements for training graphics personnel are similar to those for writing. As discussed previously, graphics is a critical and common accompaniment to written materials. Unfortunately, those factors affecting graphics comprehension are not yet well defined. However, the criticality of graphics warrants an investigation into the need for and feasibility of developing a graphics training program.

It is unclear as to what training requirements can be imposed on contracted writers of Navy materials. However, since contractors produce a large portion of written materials for Navy use, it is recommended that a determination be made of the writer training requirements which may be imposed.

In summary, the recommended R&D efforts in training programs include:

1. Determination of the most cost-effective format (e.g., schoolhouse, video tape, correspondence) for a writer training program.

2. Development of a writer training program for training in techniques of clear writing.

3. Exploratory evaluation and development of a graphics training program in techniques for development of comprehensible graphics.

4. Determination of training options for contracted writers.

MEETING THE READING ABILITY STANDARDS

Two recommendations are made with respect to reading ability. First, projected declines in reading ability, current manpower needs, and opportunities for occupational choice all suggest that personnel reading below the 9.0 grade level should be given an opportunity to reach that level. Participation in this program should be voluntary. Second, it is recommended that the 6.0 level be adopted as a minimum acceptable reading level for Navy personnel. Mandatory training in basic reading skills should be provided to personnel who read below this level. The goal of programs implemented to support these two recommendations should be to prepare personnel for occupational training. Thus, the training materials should consist of, or resemble as closely as possible, Navy reading matter relevant to Navy careers. The training should prepare personnel for the vocabulary, formats, and concepts they will encounter in the Navy.

The success of these programs will depend on how well we understand the problems of adults who read poorly. Before turning to specific goals for the two recommendations, then, it is useful to outline the current state of knowledge of the reading process.

Overview of Needed Research on the Reading Process

Reading may be roughly understood as the process of translating printed symbols into meaning. The input (the symbols) may be accurately described and understood, but, in the absence of an adequate theory of semantics, the output (meaning) will be only roughly described and understood. To understand the reading process, it is necessary to know much more than we currently do about memory, perception, and the psychology of language. It has been long recognized that an adequate description of the reading process would be a major scientific achievement.

A wide range of research can be viewed as potential support for understanding reading. The major difficulty has been to determine how specific experiments or pieces of empirical information contribute to our general knowledge of reading and reading instruction. Research in reading currently consists of a voluminous assortment of fragmented studies. Little useful information is available for integrating results of these studies into a coherent body of knowledge. Trying to extract empirical information to develop specific programs such as the two proposed here is similarly complicated, and any attempt to do so should be viewed as tentative and as requiring empirical test. In general, however, it seems reasonable to base reading instruction on the following five aspects of the reading process: perception, decoding, vocabulary, literal comprehension, and interpretive, or inferential, comprehension.

Perception. At the most fundamental level, reading is a process of visual perception. However, results of current research indicate that visual perception involves much more than the physiology of seeing. Perception is a constructive process which depends as much on the perceiver's state of knowledge as it does on the physical stimuli impinging on his senses. It is also clear that the perceiver's state of knowledge is affected by the state of his sensory organs, and dysfunction of these organs may have far more subtle and complex implications for reading ability than previously supposed. It seems reasonable, therefore, to begin a program for adult basic reading by seriously attempting to find physiological explanations for the reading problems being experienced. Current research indicates that such an attempt will require a far more extensive examination of the physiological processes of visual perception than that ordinarily administered during Navy recruitment. At the least, R&D in this area should yield techniques that can determine for each individual whether or not there are no physiological limits to improving his reading ability.

Decoding. The process of translating visual symbols to meaning in reading is mediated by language. Thus, a reader's state of knowledge relevant to the reading process can be largely accounted for by his knowledge of language, or less directly, by a description of the language in which the information is being communicated. In this sense, reading parallels and, at some level of abstraction, is equivalent to the process of speech perception. Current research indicates that for beginning readers this level of abstraction is much lower than for proficient readers. For instance, beginning readers must translate a written symbol into the phonological representation. They must, overtly or covertly, say the word before they can read it. Proficient readers have learned to streamline this process. They do not have to say a word in order to read it and they typically process "chunks" of information rather than single words. What unit is processed and at what level of abstraction is a matter for considerable investigation. Unfortunately, currently there is more speculation about this problem than there is research, and it is research, or empirical information, that is needed to understand the problems remedial readers encounter in translating written symbols to phonological or phonologically-based representations. Also, we need to know how remedial readers can be taught to process language at a more abstract level. Research of this sort generally falls under the rubric of decoding. Although proficient readers occasionally decode symbols into phonological representations, they more commonly decode symbols into a more abstract representation. We must learn to teach remedial readers to do the same.

Vocabulary. Current research on reading pedagogy indicates that the most efficient way to increase the measured reading ability of adults or children is to increase their reading vocabulary. In some cases, this is strictly a problem of decoding; readers must merely recognize written symbols as units, usually words, that are already in their speaking vocabulary. In other cases, it is a problem of simultaneously increasing their reading and speaking vocabularies; readers must understand written symbols for units and, at the same time, must encode these

units into their speaking vocabularies. In both cases, measured reading ability is increased as a concomitant of improved vocabulary. A major feature of this approach is that it works dramatically. A major problem is that it is not clear whether an improvement in measured reading ability achieved in this way represents an improvement in the ability to comprehend text, which is the appropriate target for Navy reading improvement programs. Intuitively, it seems that a program of vocabulary improvement is valid for those who must read standard English as a second language or, perhaps, as a second dialect. The validity of vocabulary improvement programs is less certain for those who are already acquainted with standard English in their listening and speaking vocabularies. In any case, programs of vocabulary improvement promise major payoffs for the Navy, and they deserve investment in R&D.

Literal Comprehension. Although payoffs for programs in increasing literal comprehension are less clear than for programs in vocabulary improvement, the former seems more directly related to the Navy's needs for increased reading ability than any other aspect of the reading process. For this reason, R&D in this area should be pursued. Roughly, literal comprehension refers to the ability to derive denotative meaning from phrases and sentences that are graduated in difficulty to accord with their vocabulary and syntactic complexity. Presumably, each individual has a repetoire of syntactic constructions of sentences that he is able to read. This repetoire has been called a reading grammar as opposed to a listening or speaking grammar. Presumably this repetoire can be increased from such kernal constructions as "The man died" to such imbedded constructions as "The man that the dog bit died" or even "The man that was bitten by the dog that was owned by the girl died." Increasing this repetoire should increase reading ability. Research on this issue is currently primitive, but the intuitive appeal of programs to increase literal comprehension argues cogently for their inclusion in any program of reading instruction. Additionally, the newer theories of linguistic description facilitate description of syntactic inputs to a program intended to increase literal comprehension. Given this facilitation, a program of this sort is more likely to achieve its goal than it might have a few years earlier.

Interpretive Comprehension. All communication oversimplifies the information that must be transmitted. Just as visual perception is a constructive process that depends as much on the perceiver's state of knowledge as on the physical stimuli being input, so the semantic information intended for transmission by reading must depend as much on the perceiver's semantic knowledge as on the denotation of the words used to communicate the information. For instance, a reader may easily disambiguate a sentence such as "Flying airplanes can be dangerous,"[9] by correctly determining from contextual cues whether the act of flying

[9]The two meanings are "Airplanes that are flying can be dangerous" and "The act of flying an airplane can be dangerous."

or the airplanes themselves are emphasized. Such interpretations can be easily made by the proficient reader despite the ambiguity inherent in the denotation of the communication.

Interpretative comprehension extends from the use of textual context to comprehend a sentence to the ability to use world experience or a specific situation to comprehend a sentence or even an entire passage. For example, in a sentence such as the following, all necessary information is intended to be communicated by the denotation of the words used: "Initial program loading is initiated manually by selecting an input device with the load-unit-address switches and then pressing the load key (IBM system/370, 1973, p. 52)." Yet demands are still being made on the reader's interpretive abilities. For instance, he is not told in the sentence or, indeed, anywhere in the section on initial program loading, that there is a one-to-one correspondence between settings of the load-unit-address switches and specific input devices. He must interpret (1) that such a correspondence exists and, (2) that he must find what these correspondences are before he can load a program "manually" from an input device. There is, then, a real need for interpretive comprehension ability in reading technical expositions and a concomitant need for training in this ability in any Navy reading program. It is not clear how and to what extent interpretive comprehension skills can be taught; these are problems for R&D.

Reading Ability and Reading Difficulty. A final comment is needed on the interaction of reading ability and reading difficulty. No functional expression exists of the extent to which a reader is handicapped if his reading ability lags behind the reading difficulty of the material he is reading. The 6.0 and 9.0 levels of reading ability on which the recommendation of this paper are based are, to some extent, arbitrary. They represent educated guesses based on the best information available, but they are still guesses. If a reader is brought up to the 6.0 level, it is still unclear if he will be functionally illiterate with respect to the Bluejackets' Manual, for instance, which has an estimated readability level of 11.5, or if he will only miss less important nuances in the information intended to be communicated by the manual. Much more R&D is needed in setting appropriate reading ability and readability standards for Navy literacy requirements.

Reading Enhancement Program

It is recommended that personnel reading below the 9.0 level be provided an opportunity to reach that level. Participation in the program should be voluntary. However, if the program is to provide increased opportunity for occupational selection and advancement and to assist personnel in meeting job reading requirements, it should be readily available to all personnel on shore and, to some extent, aboard ship and at dockside. In relying on voluntary participation, the program will capitalize on motivation to learn and will result in immediate use of what is learned.

Close cooperation between R&D activities and operational commands will be essential. Specific R&D activities necessary for implementation are the following:

1. Projection of the number of personnel who would voluntarily enter the program. This projection could be made by administering a questionnaire to samples of personnel stratified according to reading ability and duration of service.

2. Determination of the degree to which other programs, e.g., GED and Campus for Achievement, fulfill the requirements of the program. Where appropriate, existing programs and approaches will be incorporated.

3. Development of materials to be used in the program. Relevant Navy materials written at various grade levels will be found or developed, and tests for comprehension of this material will be prepared.

4. Determination of program duration and instructional objectives and procedures. Current technology and research will be surveyed to determine the state-of-the-art in reading instruction. Individualized training will be emphasized in the program procedures.

5. Implementation of instructional procedures. This activity will require the closest possible coordination between R&D personnel and operational training commands.

Basic Reading Program

It is recommended that the 6.0 reading level be adopted as a minimum acceptable reading level for Navy personnel. This standard can be attained by screening out prospective recruits who fall below the 6.0 level, by giving these recruits basic reading training, or by some combination of these two procedures. About 6.5% of recruits now entering the Navy read below the 6.0 level and this proportion may be expected to increase (NEOCS, 1974). Out of hand rejection of these recruits appears to be an untenable strategy. These considerations indicate a need for an effective basic reading program to bring personnel who are otherwise qualified for service to the 6.0 reading level.

Basic reading training is currently given at the Navy Recruit Training Centers (RTCs) to a large portion of recruits reading below the 5.5 level. This program is approximately 4 weeks long and effects a 1.5 to 2.0 reading grade level increase. Given needs for literacy training, it is recommended that this basic reading program be expanded to include all personnel reading below the 6.0 level. The goal should be to prepare personnel for the reading requirements they face in a Navy career. As such, the training should occur as early as possible, and the training materials should be derived from the materials used during recruit training. The use of simplified materials from the Bluejackets' Manual and Seamanship Manual is recommended.

The short-term R&D requirements of the basic reading program resemble those of the reading enhancement program. The following activities are required:

1. Projection of the number of recruits who would participate in the program. To some extent this requirement has already been met by the large samples of recruits studied at RTC, San Diego. Additional information from the remaining two RTCs would be useful to determine if the San Diego sample is representative of all Navy recruits and to obtain more detailed demographic information to see, for instance, how membership in different language and dialect communities affects reading skill.

2. Determination of the degree to which other programs fulfill the requirements of the basic reading program. Even though there are operational basic reading programs, extensive material development will be required. The existing programs rely on commercially available training materials. As such, the content has not been fully Navy relevant. Additionally, this training has focused on phonics, vocabulary, comprehension, and rate skills. While these skills are necessary, an emphasis on occupational preparation requires training in those skills adjunctive to reading. That is, even if a man reads well, most job reading material will not help him unless he knows how to find and interpret the necessary information. Adjunctive training in such skills as how to use indices and tables of contents and how to read tables and graphs is necessary. (See Perry & McCabe, undated, for an example of functional literacy training in industry and Sticht, 1974, for Army functional literacy training.)

3. Development of materials to be used in the program. Given an occupational training emphasis, an R&D program is needed to prepare appropriate reading, adjunctive reading skill training, and test materials.

4. Determination of program duration and instructional objectives and procedures. The needs for instructional objectives are similar to those discussed for the reading enhancement program. The objectives and training procedures already formulated in the existing programs will be modified to emphasize occupationally relevant training. While the current objectives and procedures will serve as a framework for direct training of reading, new objectives and procedures will be required for training adjunctive reading skills.

Further, an R&D effort should focus on available procedures for individualizing training within the confines of current classroom training. The increased number of men entering basic reading as well as the increased range of reading abilities and training requirements will necessitate some individualizing of programs to provide effective training. All men will not need all categories or levels of reading training. This individualization and its potential effectiveness are exemplified by a procedure implemented at RTC, San Diego. Until recently, all recruits entering the reading program progressed through the same training. Variation in rate of progression only occurred if a man was required

to repeat a unit of instruction. Under the new procedure, however, all recruits are pretested for phonics ability and, if they pass this test, they are allowed to skip the phonics training unit. As a result of this basic step towards individualization, the average training time was reduced from 4.0 weeks to 3.2 weeks. This 20% savings in training time was accomplished without a reduction in training effectiveness.

5. Implementation of instructional procedures. As in the reading enhancement program, the success of this activity will depend on as close cooperation as possible between R&D personnel and operational training commands.

Prospects and Requirements for the Future

The proposed reading training programs are recommended with some reservation. Past attempts at reading training have not met with great success and the probable success of new programs must be questioned. Early attempts at Armed Forces reading training, reviewed in Marginal Men and Military Service, (1965), failed to improve reading and, consequently, did not affect job performance. More recent programs produced significant improvement in reading ability but yielded, at best, only marginal effects on job performance as measured by retention, performance ratings, disciplinary actions, etc., (Vineberg & Taylor, 1972; Fisher, 1971). These results and the current need for reading training suggest that any reading program should be cautiously developed with a maximal R&D effort.

The proposed reading training programs offer greater hope of affecting performance and job satisfaction than previous efforts. First, a continuous program of reading training is proposed rather than a single, brief training program characteristic of previous efforts. Thus, reading training would be available throughout a man's career whenever he feels the need for such training. Second, the proposed programs would focus on Navy reading materials and train men not only in comprehending the materials but also in using them effectively. Thus, the step of transferring an improved reading ability to the effective use and comprehension of Navy occupational materials would be unnecessary. Initial training would be directly relevant. Finally, the reading training would not occur in isolation. Through the joint efforts of reading training and revising material for greater readability, personnel would achieve a level adequate for comprehending the reading matter they will face on the job.

Matching reading training to job reading requirements requires R&D of reading training materials beyond that necessary for immediate implementation of the programs. For example, training in skills adjunctive to reading was proposed for the basic reading program. Additional research is needed to determine the range of skills adjunctive to reading which may require training and to what extent such training is

required in each program. Similarly, investigation of the kinds of material personnel have difficulty in comprehending is needed. For example, such an investigation might determine to what extent the reading training should focus on general text, procedural information, and/or instructional information. Mid-term R&D efforts would, then, include the following activities:

1. Development of reading training materials.

2. Determination of adjunctive reading skills relevant to Navy careers.

3. Investigation of what material is difficult to comprehend.

R&D efforts discussed thus far have focused on ensuring that the reading training is maximally relevant to occupational reading requirements. A long-term, intensive research effort is also needed to examine the basic skill requirements for reading with comprehension and to develop training procedures relevant to developing these skills. Although there has been extensive research on the reading process for decades, we still have little understanding of the skill requirements in reading. This lack of understanding is reflected both in the theories of reading and the lack of conclusive research evidence on reading. Regarding the latter point, Chall stated that "the research on beginning reading is shockingly inconclusive (1967, p. 88)." Other researchers in the area have concurred (e.g., Levin and Williams, 1970). Theories and models of reading abound, which again points to our lack of understanding. Geyer (1972) reviewed 48 theories which are relevant to reading, and Williams (1973) examined 14 different theories of reading.

Given these considerations, it might appear that reading research is fruitless and that the critical variable is simply placing an individual in a reading environment. However, advances in theory and training technology and the fact that reading requires the same skills that are involved in these other areas leads to a rejection of this conclusion. Indeed, Atkinson (e.g., 1972, 1974) has demonstrated substantial improvements in second language vocabulary training and in several aspects of basic reading training through individualized instruction. Similarly, the experience at RTC, San Diego discussed previously indicates the effectiveness of dealing with the specific reading skills of specific individuals.

It is more likely that the failure of reading research to date stems from the lack of attention to skills directly relevant to the reading process and from the failure to systematically relate research findings to overall research progress. The effectiveness of individualization and the adaptability of current instructional technology to individualization are clearly indicated by the Atkinson and RTC, San Diego results. However, the research to date has failed to clearly specify those skills that should be trained in a comprehensive program of individualized instruction. Chall (1967) cites evidence suggesting

that the lack of effectiveness of reading research stems from the lack of systematic funding. Be that as it may, effective training requires a delineation and an understanding of the processes involved in reading.

The foregoing emphasizes that the reading process must be understood and that an effective attack requires systematic and long-term research. The Navy research effort on reading should be predicated upon an analysis of the reading task faced by Navy personnel. It is only in the context of deep and systematic empirical investigation that the two recommended programs hold serious promise for meeting the Navy's requirements for reading ability.

REFERENCES

Atkinson, R. C. Ingredients for a theory of instruction. American Psychologist, 1972, 27, 921-931.

Atkinson, R. C. Teaching children to read using a computer. American Psychologist, 1974, 29, 169-178.

Binkin, M., & Johnston, J. All volunteer armed forces: Progress, problems, and prospects. Brookings Institute Report, June 1973.

Biotechnology, Inc. Format and media considerations in the preparation of Navy technical materials (tentative). Alexandria, Va.: Biotechnology Inc., in press.

Bond, N. A. & Rigney, J. W. Baysian aspects of troubleshooting behavior. Human Factors, 1966, 8, 377-383.

Booher, H. R. The effects of still pictures and printed words on comprehension of job performance instructions. (Unpublished dissertation, Catholic University of America, 1973).

Brogan, J. A. Clear technical writing. New York: McGraw-Hill, 1973.

Brown, J. S., Burton, R. R., & Bell, A. G. SOPHIE: A sophisticated instructional environment for teaching electronic troubleshooting (An example of AI in CAI). Technical Report 2790. Cambridge, Mass.: Bolt, Beranek, & Newman, Inc., March 1974.

Byrd, K., Kidd, J., & Price, H. Analysis and evaluation of Navy avionics manuals. TR69-C-0301-1, 1970.

Carver, R. P. Measuring the reading ability levels of Navy personnel. Technical Report under contract to the Psychological Science Division, Office of Naval Research, October 1974a.

Carver, R. P. Measuring the reading difficulty levels of Navy training manuals. Technical Report under contract to the Psychological Sciences Division, Office of Naval Research, September 1974b.

Caylor, J. S., Sticht, T., Fox, L., & Ford, J. Methodologies for determining requirements of military occupational specialties. HumRRO Technical Report 73-5. Alexandria, Va.: Human Resources Research Organization, March 1973.

Chall, J. Learning to read: The great debate. New York: McGraw-Hill, 1967.

Chapanis, A. Words, words, words. Human Factors, 1965, 7, 1-17.

Conrad, R. The design of information. Occupational Psychology, 1962, 36, 159-162.

Cronbach, L. J. Beyond the two disciplines of scientific psychology. American Psychologist, 1975, 30, 116-127.

Crooks, W. H., May, D. M., Purcell, D., Lucaccini, L., & Freedy, A. Application of adaptive decision aiding systems to computer-assisted instruction. Technical Report No. PTR-1019-74-7. Woodland, Hills, Ca.: Perceptronics. Prepared for U. S. Army Research Institute for the Behavioral and Social Sciences, July 1974.

Duffy, T. M., Nugent, W., Millar, D., & Carter, J. Assessment and training of essential skills. Unpublished paper, 1974. San Diego: Navy Personnel Research and Development Center.

Dwyer, F. M. An experimental evaluation of visual illustrations used to compliment programmed instruction. University Park, Pa.: University Division of Instructional Services, The Pennsylvania State University, 1967.

Dwyer, F. M. Effect of visual stimuli on varied learning objectives. Perception and Motor Skills, 1968, 27, 1067-1070.

Dwyer, F. M. An analysis of the instructional effectiveness of visual illustrations presented via television. Journal of Psychology, 1969, 72, 61-64.

Dwyer, F. M. A guide for improving visualized instruction. State College, Pa.: Learning Services, 1972.

Fattu, N. & Standlee, L. Analysis of reading difficulty of selected Navy materials. Technical Bulletin 54-3. Bureau of Naval Personnel, March 1954.

Fisher, Jr. A. H. Army "new standards" personnel: Effect of remedial literacy training on performance in military service. Alexandria, Va.: AFHRL TR71-13, April 1971.

Geyer, J. J. Comprehensive and partial models related to the reading process. Reading Research Quarterly. 1972, 7, 541-587.

Gulliford, N. L. Current research on the relative effectiveness of selected media characteristics. Pittsburgh, Pa.: Report for Westinghouse Electric Corp., Research and Development Center, October 1973.

Gunning, R. The techniques of clear writing. New York: McGraw-Hill, 1952.

Hoyt, W. G., Butler, A. K., & Hayword, C. D. Shipboard computer integrated instruction in general damage control: Development phase. San Diego, Ca.: Navy Personnel Research and Development Center, in press.

International Business Machines Corp. IBM System/370 Principles of Operation. Poughkeepsie, New York, 1973.

Kern, R. P., Sticht, T. G., Welty, D., & Hauke, R. N. Guidebook for the development of Army training literature. Prepared for United States Army Institute under contract DAHC 19-73-C-0051, April 1974.

Kincaid, J. P., Fishburne, Jr., R. P., Rogers, R. L., & Chissom, B. S. Derivation of new readability formulas for Navy enlisted personnel. Research Branch Report 8-75. Millington, Tenn.: Naval Technical Training Command, Naval Air Station, Memphis, February 1975.

Kinton, Incorporated. Study on low cost ownership for the improvement of maintenance information presentation techniques. Aberdeen Proving Grounds, Md.: Prepared for U. S. Army Human Engineering Laboratory Contract No. DAADO5-74-C-0783, 1975.

Klare, G. R. The measurement of readability. Ames, Iowa: State University Press, 1963.

Klare, G. R. A manual for readable writing. Unpublished report. Ohio University, July 1973.

Klare, G. R. Assessing readability. Reading Research Quarterly 1974-1975, 10, 62-102.

Klare, G. R. Some suggestions for clear writing. Undated paper.

Levin, H. & Williams, J. P. (Eds.) Basic Studies on Reading. New York: Basic Books, Inc., 1970.

Loftus, G. R. & Bell, S. M. Acquisition of detail information when viewing pictures. St. Louis, Missouri: Paper presented at the Fourteenth Annual Meeting of the Psychonomic Society, 1973.

Madden, H. L. & Tupes, E. C. Estimating reading ability level from the AQE general aptitude index. Lackland Air Force Base, Texas: Personnel Research Laboratory, Aerospace Medical Division, February 1966.

Marginal man and military service, A review. Department of the Army. Office of the Chief of Research and Development, 1965.

McGoff, R. M., & Harding, F. D. A report on literacy training programs in the Armed Forces. Report MR 74-6. Alexandria, Va.: Manpower Development Division, Air Force Human Resources Laboratory, April 1974.

McKeachie, W. J. Instructional Psychology. In M. R. Rosenzweig and L. W. Porter (Eds.) Annual Review of Psychology. Palo Alto, Calif.: Annual Review Inc., 1974.

Miller, L. Navy Technical Manual Systems (NTMS) Working Paper No. 1. "Preliminary Human Factors R&D Plan" Working Paper CMD-01-75. Bethesda, Maryland: Naval Ship Research and Development Center, January 1975.

Mockovak, W. P. An analysis of Air Force reading programs: Results of USAF survey number 73-89. AFHRL-TR-73-54. Brooks Air Force Base, Texas: Technical Training Division, Air Force Human Resources Laboratory, January 1974a.

Mockovak, W. P. An investigation and demonstration of methodologies for determining the reading skills and requirements of Air Force career ladders. AFHRL/TR 73-53. Lowry Air Force Base, Colorado: Technical Training Division, Air Force Human Resources Laboratory, January 1974b.

Mowry, H., Webb, W., & Garvin, E. Readability of instructional materials and methods for analyzing. St. Louis, Missouri: NOWR Contract Research 816(02), Washington University Department of Psychology, Undated.

Naval Ship Systems Command. Military specification manuals technical: Functional oriented maintenance manuals (FOMM) for equipment and systems. Washington, D. C.: MIL-M-24100B, January 1974.

Navy Enlisted Occupational Classification System Study Group. Forward plan for the Navy Enlisted Occupational Classification System (NEOCS). Executive Summary, Vol. I. 15 January 1974.

Navy Enlisted Occupational Classification System (NEOCS) Study: Vol. II. Chief of Naval Personnel, January 1974.

Ortegeis, K. A summary of test and evaluation results on the use of symbolic integrated maintenance manuals (SIMM), Santa Ana, Calif.: Serendipity, Inc., 1970.

Perry, E. R., & McCabe, R. J. Basic education for station installers. New Rochelle, New York: Metro Education, Inc., Undated.

Post, T. J., & Price, H. E. Requirements and criteria for improving reading comprehension of technical manuals. Falls Church, Virginia: Biotechnology, Inc. Prepared for Naval Sea Systems Command, Contract N00024-74-C-5426, 1974.

RCA Inc. Study and proposal for the improvement of military information transfer methods. Lexington, Kentucky: Army Maintenance Management Center Contract #DAAD05-74-C-0782, September 1974.

Ronan, W. W. & Prien, E. P. Perspectives on the measurement of human performance. New York: Appleton-Century-Crofts, 1971.

Serendipity Inc. PIMO test summary. Norton AFB, California, Vol. II TR-69-155. Prepared under Contract No. AD852102 for Air Force Systems Command, 1969.

Siegel, A. I., & Burkett, J. R. Application of structure-of-the-intellect and psycholinguistic concepts to reading comprehensibility measurement. Technical Report AFHRL-TR-74-49. Brooks Air Force Base, Texas: Technical Training Division, Air Force Systems Command, September 1974.

Siegel, A. I., Federman, P. J., & Burkett, J. R. Increasing and evaluating the readability of Air Force written materials. Technical Report AFHRL-TR-74-28. Lowry Air Force Base, Colorado: Technical Training Division, Air Force Human Resources Laboratory, August 1974.

Sticht, T. Learning by listening in relation to aptitude, reading, and rate controlled speech. HumRRO Technical Report 69-23. Alexandria, Virginia: Human Resources Research Organization, December 1969.

Sticht, T. G. (ed.) Reading for working: A functional literacy anthology. Alexandria, Virginia: HumRRO, 1974.

Sticht, T., Beck, L., Hauke, R., Kleiman, G., & James, J. Auding and reading: A developmental model AFHRL-TR-74-36. Brooks Air Force Human Resources Laboratory, Technical Training Division, July 1974.

Sticht, T., Caylor, J., Kern, R., & Fox, L. Determination of literacy skill requirements in four military occupational specialties. Technical Report 71-23. Alexandria, Virginia: Human Resources Research Organization, December 1971.

Strong, C. W. & Edison, D. A Technical Writer's Handbook. New York: Holt, Rinehart, and Winston Inc., 1971.

Sulit, R. Navy Technical Manual System Program Summary. TM-186-75-1. Bethesda, Maryland: Naval Ships Research and Development Center, January 1975.

Taylor, W. L. "Cloze" readability scores as indices of individual differences in comprehension and aptitude. Journal of Applied Psychology, 1957, 41, 19-26.

Vineberg, R. & Taylor, E. Performance in four Army jobs by men at different aptitude (AFQT) levels 3: The relationship of AFQT and job experience to job performance. HumRRO Technical Report 72-22, August 1972.

Wells, R. F., Von Mondfrans, A. P., Postlehwait, A., & Butler, D. C. Effectiveness of three visual media and two study formats in teaching concepts involving time, space, and motion. AV Communication Review, 21, No. 2, 1973.

Williams, J. P. Learning to read: A review of theories and models. Reading Research Quarterly, 1973, 8, 121-146.